NASA/GSFC	MISSION OPERATIONS & DATA SYSTEMS DIRECTORATE (MO&DSD) CONFIGURATION CHANGE REQUEST (CCR)			
1. CCR NO. 2002	CCR-530-WSC-02	**2. DATE** 11 November 1996	**3. PRIORITY** ☐ EMERGENCY ☐ URGENT ■ ROUTINE	**4. CHANGE LEVEL** ☐ A ☐ B ☐ C ■ D ☐ E ☐ F

5. TITLE OF CHANGE

KSHR Channel-1 Rate - 1/3 Decoding and WSC STS CMD Echo Clarification

6.

DOCUMENT TITLE Requirements Specification for the White Sands Complex (WSC)
1 September 1996

Approved

DOCUMENT NO. 530-RSD-WSC

LIST ALL AFFECTED DOCUMENTS INCLUDING PROCEDURES 405-TDRS-RP-SY-011 4/2/97
White Sands Complex (WSC) Ground Terminal Requirements for the TDRS H, I, J Era

(CONT ON ATTACHMENT)

7. REASON FOR CHANGE

Change Specification for KSHR Channel-1 to Rate - 1/3 Coded, as the SSHR BPSK Channel and clarification of STS S-CMD and K-CMD Echo for WSC.

(CONT ON ATTACHMENT)

8. DESCRIPTION OF CHANGE

Pages 3-10, 3-11, 5-63, 5-99, 5-101, 5-108, 5-109, 5-111, 5-117, and 8-28.

(CONT ON ATTACHMENT)

9. IMPACT

YES	NO	SYSTEM	YES	NO	SYSTEM	YES	NO	SYSTEM
	■	501	■	☐	530	☐	■	MSFC
☐	■	502	☐	■	540	☐	■	JSC
☐	■	503	■	☐	550	☐	■	LERC
☐	■	510	☐	■	560	☐	■	KSC
☐	■	520	■	☐	OTHER	☐	■	JPL

YES	NO	
☐	■	CODE E
☐	■	CODE S
☐	■	CODE T
☐	■	OTHER

10. COMMENTS

	SIGNATURE	DATE
STel ANALYST		
HARDWARE ENGINEER		
OPERATIONS REPRESENTIVE		
SYSTEM ENGINEER		
I AND T MANAGER		

CONCURRENCE:

CODE 215

DATE

11. BOARD ACTION

☐ APPROVED ☐ WITHDRAWN
☐ DISAPPROVED ☐ DEFERRED UNTIL _____

12. DIRECTION/ACTION REQUIRED

☐ ECP ☐ TECH DIRECTION ☐ CONTRACT MOD
☐ WAIVER ☐ PUBLISH DOCUMENT ☐ PUBLISH DCN
☐ DEVIATION ☐ C.O. LETTER ☐ OTHER _____

13. ORIGINATOR D. Littmann X7643 CODE 530.4
SIGNATURE _____ DATE _____

14. SEGMENT MANAGER'S APPROVAL CODE _____
SIGNATURE _____ DATE _____

15. CCB APPROVAL
SIGNATURE _____ DATE _____

16. CCR IMPLEMENTED
ATR SIGNATURE _____ DATE _____
CCB SIGNATURE _____ DATE _____

Table 3-5. TDRSS Shuttle Unique Service Signal Characteristics (Cont'd)

PARAMETER	FORWARD	RETURN
I-CHANNEL (CHANNEL 3):		
MODULATION	N/A	PSK, ± 90°
DATA FORMAT	N/A	NRZ-L,M,S
CONVOLUTIONAL ENCODING	N/A	RATE 1/2
DATA RATE	N/A	2-50 Mbps, OR NO DATA
Q-CHANNEL:		
MODULATION	N/A	QDSB
DATA FORMAT	N/A	8.5 MHz SQUARE WAVE SUBCARRIER QPSK MODULATED WITH DATA
SUBCARRIER MODULATION:		QPSK
I-CHANNEL (SUBCARRIER) Q-CHANNEL (SUBCARRIER)	N/A	4.3 dB
I-CHANNEL (CHANNEL 2):		
DATA FORMAT	N/A	NRZ-L,M,S; ALL DATA RATES BIPHASE-L,M,S ≤ 1.024 Mbps
DATA RATE	N/A	16 kbps-2 Mbps
Q-CHANNEL (CHANNEL 1):		
DATA FORMAT	N/A	NRZ-L~~BIPHASE-L~~
CONVOLUTIONAL ENCODING	N/A	RATE 1/3, CONSTRAINT LENGTH K=7, CONVERSION TO BIPHASE-L REQUIRED
DATA RATE	N/A	192 kbps
MODE 2		
MODULATION	N/A	FM
SIGNAL FORMAT INTO FM MODULATOR	N/A	ANALOG MODULATED CARRIER AND 8.5 MHz QPSK MODULATED SUBCARRIER
CARRIER FM DEVIATION FREQUENCY	N/A	11 MHz PEAK
SUBCARRIER FM DEVIATION FREQUENCY	N/A	6 MHz PEAK
FM PREDETECTION 3 dB BANDWIDTH	N/A	50 MHz

Table 3-5. TDRSS Shuttle Unique Service Signal Characteristics (Cont'd)

PARAMETER	FORWARD	RETURN
CARRIER MODULATION:		
DATA FORMAT (CHANNEL 3)	N/A	ANALOG
DATA 3 dB BANDWIDTH (CHANNEL 3)	N/A	4.2 MHz
SUBCARRIER MODULATION:		
I-CHANNEL (SUBCARRIER) Q-CHANNEL (SUBCARRIER)	N/A	4.3 dB
I-CHANNEL (CHANNEL 2):		
DATA FORMAT	N/A	NRZ-L,M,S; ALL DATA RATES BIPHASE-L,M,S ≤ 1.024 Mbps
DATA RATE	N/A	16 kbps-2 Mbps
Q-CHANNEL (CHANNEL 1):		
DATA FORMAT	N/A	NRZ-L~~BIPHASE-L~~
CONVOLUTIONAL ENCODING	N/A	RATE 1/3, CONSTRAINT LENGTH K=7, CONVERSION TO BIPHASE-L REQUIRED
DATA RATE	N/A	192 kbps

3.2.5 Tracking Services

Each SGLT with an assigned TDRS can provide both two-way range and range rate (Doppler) measurements and one-way Doppler measurements for customer spacecraft. Range measurements require use on the return service of a PN range code which is coherent with the forward service range channel PN code. Two-way Doppler measurement requires use of a carrier on the return service which is synchronized with the forward service carrier. Tracking service requires establishment of a forward service and/or a return service to a customer spacecraft using either the MA, SSA, or KSA services.

3.3 Service Operations

Figure 3-2 provides an overview of a customer's Mission Operations Control Center (MOCC)/Data Processing Facility functional interfaces (command and telemetry) with the TDRSS and the functional operational interfaces with the Network Control Center (NCC). The

b. The SSA-1R and SSA-R2 service chains shall be completely independent (i.e., SSA-1R service chains (prime and redundant) shall not be interchanged with SSA-2R service chains (prime and redundant)).

c. SSA-1R service chains shall only be associated with SSA-1F service chains and not with SSA-2F service chains; SSA-2R chains shall only be associated with SSA-2F service chains and not with SSA-1F service chains.

d. The selection of prime and redundant return service chains shall be independent of the selection of prime and redundant forward service chains.

e. Each of the SSAR service chains shall be of identical design and shall be capable of receiving the input signals at the assigned frequency (SSA-1R or SSA-2R).

f. Each SSAR service chain shall be configurable to receive RF test signals from the PMMS and to distribute baseband output test signals to the PMMS.

g. Interfaces with the MA service equipment shall be provided as required to support cross support communications and tracking services.

5.3.2.1.2 KSAR Overview and Architecture

The USS KSAR reference architecture is shown in Figure 5-13. Each of the two KSAR services per SGLT shall be provided by independent equipment chains capable of processing customer return service data from RF to baseband. The KSAR equipment chains shall also support range and Doppler tracking services (Section 5.3.3).

The USS shall include the capability for continuously monitoring, and periodically reporting, equipment status, service performance status, and the quality of KSAR customer data during a scheduled service. Customer data quality assessment shall be accomplished by dedicated Data Quality Monitors (DQMs).

For each of the KSA-1R and KSA-2R services, the KSAR USS ground equipment shall include one prime equipment chain with a 100% redundant equipment chain. Each equipment chain shall be capable of supporting a normal customer service (KSAR) and a Shuttle customer service (~~S~~KSHR), but not both simultaneously. Each such equipment chain shall be referred to as a KSAR service chain. The KSA-2R service chains shall receive a Ku-band signal (polarization 2) from the RF Power Divider shown in Figure 5-13. The KSA-1R service chains shall receive a Ku-band signal (polarization 1) from the Antenna Subsystem. The following architectural requirements shall apply:

a. For each of the KSA-1R and KSA-2R services, the USS ground equipment shall include one prime service chain with a 100% redundant service chain; the components of each service chain shall each be dedicated to either the prime or the redundant KSAR service chain, and shall not be interchanged between the service chains.

Table 5-40. KSHR Service Signal Parameters

A. MODE 1	DATA CHANNELS 1, 2, 3
1. CARRIER MODULATION	QDSB
2. I CHANNEL (CARRIER) POWER Q CHANNEL (CARRIER) POWER	6 dB
3. I-CHANNEL (CARRIER)	CHANNEL 3
(A) MODULATION	PSK ± π/2 RADIANS
(B) DATA FORMAT	NRZ-L, M, S
(C) DATA RATE	2 Mbps - 50 Mbps, OR NO DATA
(D) DATA CODING	CONVOLUTIONAL, NONSYSTEMATIC TRANSPARENT, RATE 1/2, CONSTRAINT LENGTH K=7, G_1 = 1111001, G2 = 1011011; SYMBOLS GENERATED FROM G2 WILL BE COMPLEMENTED. ENCODER CONSISTS OF 5 PARALLEL ENCODERS AS SPECIFIED IN SECTION 5.3.2.3.2.3.B.4.
4. Q-CHANNEL (CARRIER)	
(A) MODULATION	8.5 ± .0006 MHz SQUARE WAVE SUBCARRIER, QPSK MODULATED WITH CHANNEL 1 AND CHANNEL 2 DATA.
(B) I CHANNEL (SUBCARRIER) POWER Q-CHANNEL (SUBCARRIER) POWER	4.3 dB
(C) I-CHANNEL (SUBCARRIER)	CHANNEL 2
(1)DATA RATE	16 kbps - 2 Mbps OR NO DATA
(2)DATA FORMAT	NRZ-L,M,S ALL DATA RATES Biφ-L, M, S ≤ 1.024 Mbps
(D) Q-CHANNEL (SUBCARRIER)	CHANNEL 1
(1)DATA RATE	192 kbps~~, 576 ksps (NO REQUIREMENT TO DEMODULATE 576 ksps, I.E., ALWAYS CONFIGURED FOR 192 kbps)~~
(2) DATA CODING~~FORMAT~~	CONVOLUTIONAL; RATE 1/3; CONSTRAINT LENGTH 7 G1: 1111001 G2: 1011011 G3: 1100101
(3) DATA FORMAT	NRZ-L
(4) SYMBOL FORMAT	Biφ-L
B. MODE 2	ANALOG/VIDEO CHANNEL 3 DATA CHANNELS 1, 2
1. CARRIER MODULATION	FM

Table 5-40. KSHR Service Signal Parameters (Continued)

2. ANALOG/VIDEO CHANNEL 3	
(A) DATA FORMAT	ANALOG
(B) DATA 3 dB BANDWIDTH	4.2 MHz
3. SUBCARRIER MODULATION	8.5 ± 0006 MHz SINUSOIDAL SUBCARRIER, QPSK MODULATED WITH CHANNEL 1 AND CHANNEL 2 DATA.
(A) I CHANNEL (SUBCARRIER) POWER Q-CHANNEL (SUBCARRIER) POWER	4.3 dB
(B) I-CHANNEL (SUBCARRIER)	CHANNEL 2
(1) DATA FORMAT	NRZ-L,M,S ALL DATA RATES Biφ-L, M, S ≤ 1.024 Mbps
(2) DATA RATE RESTRICTIONS	16 kbps - 2 Mbps OR NO DATA
(C) Q-CHANNEL (SUBCARRIER)[1]	CHANNEL 1
(1) DATA RATE~~FORMAT~~	192 kbps~~Biφ-L~~ ~~192 kbps, 576 ksps (NO REQUIREMENT TO DEMODULATE 576 ksps, I.E., ALWAYS CONFIGURED FOR 192 kbps)~~
(2) DATA CODING~~RATE~~	CONVOLUTIONAL; RATE 1/3; CONSTRAINT LENGTH 7 G1: 1111001 G2: 1011011 G3: 1100101
(3) DATA FORMAT	NRZ-L
(4) SYMBOL FORMAT	Biφ-L

NOTES

[1]EACH SERVICE CHAIN MUST BE CAPABLE OF PROCESSING KSHR MODE 1 AND 2 CHANNEL 1 WITH THE FOLLOWING ALTERNATE PARAMETERS:

(1) DATA RATE 192 kbps

(2) DATA CODING NONE

(3) DATA FORMAT Biφ-L

IT IS NOT REQUIRED THAT THIS CONFIGURATION BE ACHIEVABLE VIA ADPE CONTROL. THE NOMINAL ADPE CONFIGURATION WILL BE THE RATE-1/3 CODED CHANNEL FOUND IN THE BODY OF THIS TABLE.

5.3.2.3.2.2 Input Signal Characteristics

The signal characteristics of the received KSAR signal shall be as specified below:

a. Input Power Levels. The total received isotropic power (customer signal plus customer-to-TDRS AWGN) at the SGLT Ku-band antenna will be as follows for clear sky conditions, where the clear sky noise temperature is defined as 100°K:

1. Minimum KSA1 -141.63 dBmi.

(e) The relationship between the data rate and the number of branch encoders is as follows.

$n = R/(2 \times 10^7)$ Rounded to next higher integer if $n \neq$ integer

where n = number of branch encoders for the I Channel encoder and for the Q Channel encoder

R = channel data rate (bps).

c. DG1 and DG2 - Dual Data Channels.

1. QPSK; uncoded or coded.

(a) Two independent data signals, one on the I Channel and one on the Q Channel.

(b) Either data signal, or both, may be either uncoded or convolutionally coded.

(c) For a coded data signal, on the dual data channel, the data signal will be convolutionally encoded, using an n-parallel encoder prior to incorporating the encoded output symbols on either the I or Q Channels. The relationship between the customers data rate and the number of branch encoders is as follows:

$n = R/(1 \times 10^7)$ rounded to the next higher integer if $n \neq$ integer

where n = number of branch encoders within the convolutional encoder

R = channel data rate (bps).

d. KSHR - Three Channels. The KSHR data configurations are defined in Table 5-40.

5.3.2.3.2.4 Decoding Requirements

The KSAR service equipment shall be capable of the following decoding requirements:

a. KSA Channels and KSHR Mode 1 Channel 3.

1a. Convolutional, nonsystematic, transparent.

2b. Rate: 1/2.

3c. Constraint Length: K = 7.

4d. Generator Functions: $G_1 = 1111001$
$G_2 = 1011011$.

5e. Symbols generated from G_1 will precede symbols generated from G_2 relative to the data bit period.

6f. Symbols generated from G_2 will either be true or complemented as defined by the SHO.

b. KSHR Mode 1 and 2, Channel 1.

1. Code 4: convolutional, nonsystematic, nontransparent.

2. Rate: 1/3.

3. Constraint Length: K = 7.

4. Generator Functions: $G_1 = 1111001$
$G_2 = 1011011$
$G_3 = 1100101$.

5. Symbol sequence from the convolutional coding will be symbols generated from G_1, G_2, and G_3 successively relative to the data bit period.

5.3.2.3.2.5 Ambiguity Resolution

a. Data Phase Ambiguity. Data Phase Ambiguity is the uncertainty that the logical sense of the data may be either true or complemented. The data phase ambiguity shall be resolved for all configurations and modes except when the data format is NRZ-L for coded operation and when the data format is either NRZ-L or Biphase-L for uncoded operation.

b. Data Channel Ambiguity. Data Channel Ambiguity is the uncertainty that the I Channel or Q Channel may appear on the USS/DIS interface port designated for the I Channel data, and conversely, the Q or I Channel data may appear on the port designated for the Q Channel. The data channel ambiguity shall be resolved for all configurations and modes except for DG2 dual data channel operation with QPSK, data channel ambiguity shall be resolved for this case if at least one of the following conditions apply.

1. I/Q (power) is 4:1.

2. One data channel is coded, the other channel is uncoded.

3. One channel symbol rate differs by more than 25% from the other channel symbol rate.

c. Data Delay Ambiguity Resolution. The KSAR signal processing algorithms shall not introduce (e.g., via buffering, queuing, clocking, etc.) data delay ambiguities greater than 25% of a symbol duration.

5.3.2.3.2.6 Probability of Error (P_E)

The following probability of error (P_E) requirements shall apply:

a. For the range of error probabilities specified below, the following P_E performance shall be achieved:

$C/N_o = E_b/N_o + 10 \log R_b + L(P_E, R_b)$;

where: • $10^{-7} \leq P_E \leq 10^{-5}$.

2. DG1; Balanced QPSK; Single Data Channel. The total C/N_o is in accordance with the formulation in Item a; a maximum 0.1 db additional implementation loss relative to Table 5-41 and 5-42 shall be allowed.

3. DG1; Unbalanced QPSK; Single Data Channel. The total C/N_o is the sum of the I and Q Channel C/N_os where only the strong channel C/N_o is in accordance with the formulation in Item a.

4. DG2; SQPSK; Single Data Channel. The total C/N_o is in accordance with the formulation in Item a.

5. KSHR.

   (a) Mode 1: Three Digital Data Channels. The specified P_E performance for Channels 1, 2, and 3 shall be $P_E = 10^{-7}$, and shall be achieved with a total C/N_o equal to or greater than the minimum specified for Mode 1 acquisition in Table 5-43.

   (b) Mode 2: Two Digital Data Channels, One TV/Analog Channel. The specified P_E performance for Channels 1 and 2 shall be $P_E = 10^{-7}$, and shall be achieved with a multiburst test signal present on Channel 3, and with a total C/N_o equal to or greater than the minimum specified for Mode 2 acquisition in Table 5-43.

Table 5-41. KSAR and KSHR Allowable Implementation Loss, $L(P_E, R_b)$ - Coded Performance

DATA CHANNEL BIT RATE R_b (Mbps)	E_b/N_O = 4.2 dB $P_E = 10^{-5}$	E_b/N_O = 4.8 dB $P_E = 10^{-6}$	E_b/N_O = 5.4 dB $P_E = 10^{-7}$
0.001	2.5	2.7	3.0
0.01	2.5	2.7	2.9
0.1	2.5	2.7	2.9
1	2.5	2.7	2.9
10	2.5	2.7	3.1
75	3.0	3.2	3.7
150	3.2	3.4	3.9

NOTES

FOR DG1 MODES 1, 2 AND I CHANNEL OF MODE 3, AN ADDITIONAL IMPLEMENTATION LOSS NOT TO EXCEED 0.5 dB SHALL BE ALLOWED.

FOR NRZ-M AND NRZ-S DATA FORMATS, AN ADDITIONAL IMPLEMENTATION LOSS OF 0.1 dB SHALL BE ALLOWED.

FOR DATA BIT JITTER OF 0.1% AN ADDITIONAL IMPLEMENTATION LOSS OF 0.2 dB SHALL BE ALLOWED.

d. Symbol/Decoder Synchronization (Rate -1/2 Coded Data Only). Symbol/Decoder Synchronization time shall be measured from the time carrier acquisition is achieved to the time decoder synchronization is achieved. Decoder synchronization is achieved when the Viterbi decoder has selected and implemented the correct blocking of the input symbols (into groups of (G1, G2) symbol pairs). Requirements for bit error probability and symbol slipping take effect at the time decoder synchronization is achieved.

For the purposes of decoder synchronization, the minimum data bit transition density is 64 randomly distributed data bit transitions within any sequence of 512 data bits with no more than 64 consecutive data bits without a transition. For the minimum symbol and data transition densities and the minimum specified C/N_o values required for 10^{-5} P_E performance, the time to achieve symbol/decoder synchronization (in seconds) shall not exceed the following specified values:

1. Biphase symbol formats: 1100/(data rate in bps), with 99% probability.

2. NRZ symbol formats: 6500/(data rate in bps), with 99% probability.

e. Shuttle Subcarrier Acquisition. Shuttle subcarrier acquisition shall occur when Channel 2 does not contain data modulation. For this unmodulated channel, the symbol transition density is zero thus precluding symbol synchronization as described in c. above. After subcarrier acquisition, subcarrier tracking shall be maintained for this configuration.

f. Symbol/Decoder Synchronization (KSHR Mode 1 and 2, Channel-1 Only). Symbol/Decoder synchronization time shall be measured from the time subcarrier acquisition is achieved to the time decoder synchronization is achieved. Decoder synchronization is achieved when the Viterbi decoder has selected and implemented the correct blocking of the input symbols (into groups of (G1, G2, G3) symbol triplets), and the correct polarity of the input symbols. Requirements for the bit error probability and symbol slipping take effect at the time decoder synchronization is achieved.

For the purposes of decoder synchronization, the minimum data bit transition density is 64 randomly distributed data bit transitions within any sequence of 512 data bits with no more than 64 consecutive data bits without a transition. For the minimum symbol and data transition densities and the minimum specified C/N_o values required for 10^{-7} P_E performance, the time to achieve symbol/decoder synchronization (in seconds) shall not exceed the following specified values:

1. 1600/(data rate in bps), with 99% probability.

5.3.2.3.2.8 Bit Slippage

a. Normal Transition Density. The mean time between slips caused by a cycle slip in the symbol clock recovery loop shall be either no less than 90 minutes or no less than 10^{10} clock cycles, whichever is greater, for the C/N_o required for 10^{-5} P_E performance. This requirement applies for transition densities of at least 40% for NRZ symbols and any transition density for biphase symbols.

b. Low Transition Density. The mean time between slips caused by a cycle slip in the

8.2.8 Shuttle Unique Functions

Two independent sets of Shuttle Unique Equipment (SUE) shall be capable of providing support for two simultaneous Shuttle missions. Figure 8-8 shows a reference configuration for one SUE. Each SUE shall be capable of simultaneously processing one forward and one return data signal for one Shuttle mission, with forward data rates of 32 kbps, 72 kbps, and 216 kbps and return data rates of 96 kbps and 192 kbps. The forward and return inputs to the SUE, i.e., S-band or K-band, shall be independently selectable from the TOCC DIS Workstation. Each SUE shall be capable of processing Shuttle command echo of the 72 kbps command/voice component of the K-band forward data signal for one Shuttle mission. Reconfiguration (OPM-03) and failover, subsequent to TOCC operator selection of SUE inputs, shall be based on the current operator selected configuration. A manual switching capability shall be provided for Shuttle audio failover switching to allow the voice output signals from either SUE to be connected to the appropriate CC input ports.

Each SUE shall output the following five signals: Return Voice 1, Return Voice 2, Conferenced (forward/return) Voice 1, Conferenced (forward/return) Voice 2, and K-CMD Echo.

The K-CMD Echo from the SUE and the S-CMD Echo from the JSC Demux shall be sent to the JSC via the Communications Switch Multiplexer input ports.

The Communications Switch Multiplexer port addresses for the S-CMD and K-CMD Echo to JSC shall be different for Danzante and Cacique. Simultaneous S-CMD or K-CMD Echo shall not be required for a single Ground Terminal.~~Shuttle forward and return data signal structures are defined in Sections 4.2.2, 4.2.4, 4.2.6, and 4.2.7 of Space Shuttle Interface Control Document Level II, "JSC/GSFC Space Shuttle RF Communications and Tracking," ICD No. 2-0D004.~~

8.2.8.1 Decryption

Encrypted Shuttle forward data signals shall be routed by the Black Data Switch to the MYK-12 decryptor. These data signals shall be converted from black to red by decryptors, and the resultant red signals shall be provided as inputs to Data Quality Monitors (DQMs) and to demultiplexers.

8.2.8.2 Shuttle Data Quality Monitoring

The DQMs shall perform bit error measurements on the frame sync words of the multiplexed Shuttle forward and return data signals. DQM for the Shuttle return data shall be provided by the DQMs in the USS. The measurement results shall be reported to the Executive ADPE Subsystem supporting the Shuttle service.

8.2.8.3 Shuttle Voice Signal Extraction

The Shuttle forward and return data signals shall be demultiplexed and the digital voice signals extracted. The digital voice signals shall be D/A converted by delta demodulators, using the modified Abate algorithm defined in Section 4.2.1 of ICD No. 2-0D004.

Note 1, SEABROOK, 04/04/97 04:45:20 PM
4/2/97